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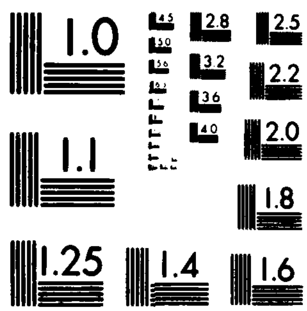

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The system described in this paper is a small microcomputer system being developed for the cataloging of graphical and nongraphical cartographic data describing the sources available and/or used in constructing maps and charts. The system is envisioned as a useful method to cartographic managers for reviewing sources belonging to an agency and determining what sources to use in a new or revised map product.

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CIMS: THE CARTOGRAPHIC INFORMATION MANAGEMENT SYSTEM

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BIOGRAPHICAL SKETCH

Jeff Ingram is a Cartographer with the Defense Mapping Agency Inter American Geodetic Survey (DMA IAGS), where he is responsible for automated cartography support to IAGS and the Latin American countries served by IAGS. He received his M.A. from the Ohio State University. His cartographic interests include cartographic data structuring and interactive cartography. Mr. Ingram is a member of ACSM and ASP.

Bob Simms is the El Salvador Project Chief with the Defense Mapping Agency Inter American Geodetic Survey. He has worked with IAGS for over 32 years in most phases of mapping, charting and geodesy. During this period he has worked with cartographic institutes in 18 Latin American countries. Mr. Simms is a fellow member of ACSM, a member of ASP, and a past director of the Panama and Central American Regioı of ASP.

ABSTRACT

The Cartographic Information Management System (CIMS) under development by the IAGS, is a unique microprocessor-based graphic system to allow storage, query and display of cartographically significant information. The system is being designed to demonstrate to the Latin American associates of IAGS a method of storing information describing photography, basic control, ground features in transition (roads, railroads, urban areas, etc. under construction, being modified or being proposed) and many other types of cartographic information necessary for maintaining up-to-date maps over their national territories. Information in the system is geographically referenced to user selected map/chart series (e.g., 1:50,000, 1:100,000, etc.). The system will be a natural planning tool for the managers of the national mapping agencies to answer questions about the location and validity of cartographic control and photographic holdings and to display numerous other types of cultural and topographic data considered in producing map products. The system is not limited to the management of cartographic sources used in producing maps and can be used for managing and displaying population data, land use information, property ownership and many other types of data. The CIMS system is small, inexpensive, relatively insensitive to its environment, and yet it will provide a meaningful capability to Latin American mapping agencies.

INTRODUCTION

The 1970s brought a veritable explosion in the amount of cartographic information produced in Latin America. In turn, the vast amount of information that was involved led to problems with how to efficiently structure the information, how to store it and how to use it. If the value of information can be readily communicated to its user, more effective use of it can be expected. This paper will concentrate on the management of information to improve its use in producing conventional map type products.

To use geographically related information, systems were developed for land use inventory (e.g., the Canada Geographic Information System and the Minnesota Land Management Information System (Tomlinson et al, 1976), selection of transportation routes (Moellering et al, 1977), exchanging and displaying statistical information to aid governmental decision making (Zimmerman, 1979) and for various other types of geographic information use.

Large-scale information systems may cover large amounts of information such as the Land Identification and Information Management System (LIMS) which is projected to handle 530,000 legally defined parcels of land in San Diego County, California (Pyle and Dietz, 1979). The Soil Conservation Service of the U.S. Department of Agriculture plans to have a large-scale information system by collecting information over the entire United States to create a national soils data base that can be used in managing the soil (Johnson, 1979).

Small-scale information systems can be used in planning the optimum location of rural health care clinics based upon the number of persons in an area, the amount of travel time to the proposed clinic and other relevant factors (Bosanac et al, 1979). The management of information relating to a national park proves valuable to park administrators in planning the different uses for the land as well as adverse impacts (Sudia and Dinkel, 1979).

The IAGS began a modernization program in 1978 to provide training and assistance in assimilating cartographic technologies such as analytical photogrammetry, image processing, satellite geodesy and computer-assisted cartography. From IAGS, Latin American cartographic/geographic institutes can obtain training and technical assistance to suit their capabilities and national needs.

Many Latin American countries completed first time topographic mapping in the late 1960s and continued into second and third editions and map scale changes over populated areas. Large amounts of cartographic information, necessary for initial and subsequent map construction, were collected with little effort to systematize the information so that institute managers could rapidly determine what cartographic information they had. The improvement in the speed and quality of decision making has been so promising with automation that IAGS decided in 1980 to demonstrate how to use a small computer in managing the information holdings of a mapping institute. The result is the Cartographic Information Management System (CIMS), a small-scale system conceived to computer-assist the management of data (e.g., photography holdings, cartographic control such as bench-marks, triangulation and gravity stations, photographically derived control, etc.) and to improve the quality of information upon which managers make decisions. The CIMS is a microprocessor-based graphic system that is small and inexpensive without being as environmentally sensitive as many minicomputer systems can be (Figure 1). CIMS can provide in-house processing and management capabilities to many Latin American institutes with software provided by IAGS. CIMS can also allow institutes to begin inexpensive automation at a basic level to develop skills and knowledges prior to consideration of larger digital cartography systems in their national programs.

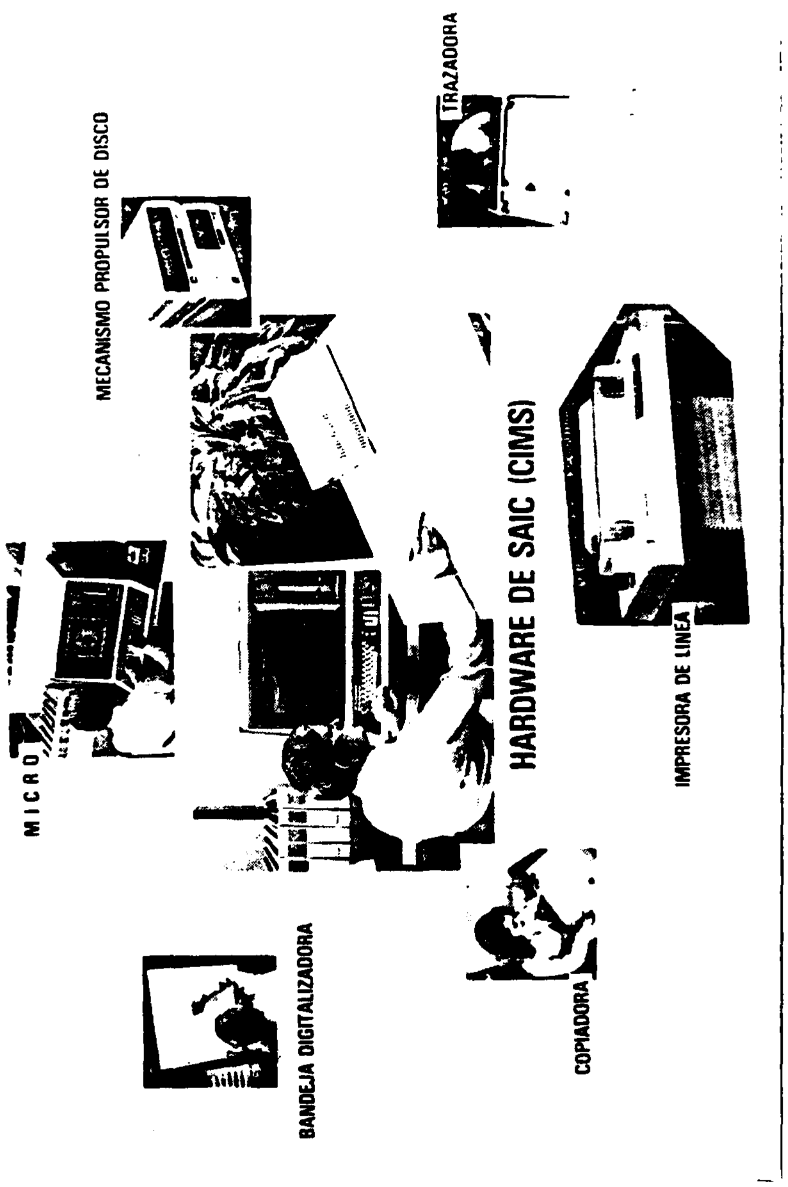
CONCEPTUAL DESIGN

The interaction of man and machine combines the advantages of the person and the machine into an entity that exceeds the capabilities of either alone (Moellering, 1975). The intent of man-machine communication is to allow each partner to work on a problem in a manner that best suits each partner. The ideal relationship was first described by Licklider as Man-Computer Symbiosis (1960). Man was to set goals, formulate hypotheses, determine criteria and evaluate results while the computer did routine type work that prepared the way for insights and decisions in technical and scientific thinking.

Foley and Wallace (1974) described the prime consideration of man-machine communication as naturalness. Naturalness occurs in a system when the interaction between the user and the machine is similar to the everyday interactions between the user and other humans. Treu (1976) added to the ideas of Foley and Wallace by emphasizing "natural but improved" man-machine interaction where the user expects a logical command language, feedback during periods of long delay, predictability of responses, system consistency and other factors that may or may not be present in day-to-day human interaction.

Designing and constructing an interactive system or purchasing an "off-the-shelf" system both require considerable attention to the man-machine interface. Research in the fields relevant to the design of an interactive system (e.g., human factors, ergonomics and cybernetics) has helped manufacturers design more efficient systems.

How information is best presented to the system user, the amount of information the user can retain, the time needed to recognize a character and the user's memory functions are understood (Sperling, 1963; Connor, 1972; Wescourt and Atkinson, 1973; Corballis and Miller, 1973). The user's performance in problem solving as affected by workload and feedback has also been researched (Knowles et al, 1969; Cumming and Croft, 1973; Miller, 1965; Hammond and Summers,



THE CARTOGRAPHIC INFORMATION MANAGEMENT SYSTEM
(SISTEMA ADMINISTRATIVO DE INFORMACION CARTOGRAFICA)

Figure 1

1972). Information on efficient cursors, data encoding, fonts and problems with font generation is generally known (Vartabedian, 1971; Goodwin, 1973; Fingeret and Brogden, 1973; Deininger et al, 1966; Hull, 1975; Maddox et al, 1977; Vitz, 1966).

The CIMS system is an off-the-shelf system that is being adapted to cartographic management applications. Because the system is not being constructed for this particular application, its selection is based upon what is known of man-machine communication. The hardware and software combination will be selected to insure that the system provides maximum human engineering for a modest price.

The origin of CIMS goes back to a manual, graphical indexing method advocated in the late 1950s by USGS. CIMS was designed in three phases, a manual, semi-automated and fully automated system (Simms et al, 1980). The manual phase is based on the USGS concept and consists of overlays keyed to a base map. The overlays graphically describe the information over the base map (e.g., photography coverage, cartographic control, major changes between map editions, indices of other maps/charts over the base map, etc.). An example of the manual phase to be found in the literature is the Overlay Information System used in Prince William County, Virginia (Archer, 1980). A similar manual system was introduced in Costa Rica by IAGS in 1975 (Simms, 1975).

The second phase or semi-automated phase is the subject of this paper. The semi-automated phase is designed to apply automation to the most basic information used in producing map products. No attempt is made to carry a large amount of digital data for each sheet, but rather the minimum amount for decision-making. The system can be easily expanded to satisfy increasing user requirements for more digital data. The system used in the semi-automated phase is a microprocessor with high resolution graphic display, digitizer, digital plotter, magnetic disk drive, line printer and display hardcopier. The system software is a conventional drafting/cartographic package. The software will be modified to perform the analytical functions necessary for CIMS to aid a decision-maker.

The third phase or the fully automated system may be some time in the future, if at all, and will occur when all of the holdings, maps, etc. are in digital form. At that point the system can be used to solve and display cartographic and non-cartographic problems. From its information base and increased analytical powers, photographic missions can be laid out and costs determined, the cost of materials for producing any map product can be determined, future mapping programs can be designed and so on. All of this is done interactively with the results displayed and modified until the problem is most efficiently solved. This phase is recognized as a difficult and expensive goal and it may not be possible or desirable for many Latin American countries.

THE CARTOGRAPHIC INFORMATION MANAGEMENT SYSTEM

System Rationale

Interactive computer-assisted cartography offers the cartographer a very powerful tool to perform his tasks. He views and manipulates a cartographic image essentially in real time. The image, termed a non-map by Yoeli (1975), temporary map by Riffe (1970) or virtual map by Moellering (1975) can be relatively quickly modified on the CRT display without altering the data underlying the virtual image. This is the central theme of the CIMS system. A manager in a mapping institute can display combinations of information covering a unique sheet in a series to make decisions on when to produce a new edition, whether or not new photography needs to be flown, what control exists and where it is located and so on. As he is viewing a virtual image, he can easily redraw the image to highlight information over a map. The possible changes to the virtual image are quite extensive as the image can be rescaled, detected errors can be corrected, new information can be added, various combinations of data can be displayed and so on.

The CIMS system is small, inexpensive and very tolerant of temperature, humidity and power variations. The system is sufficiently accurate and physically capable of handling the tasks envisioned with acceptable rates of speed. The commercial software, while general in nature, provides the drawing foundation needed for most cartographic purposes. IAGS will modify the CIMS software to allow analytical problem solving (e.g., displaying photography coverage over a sheet between 1975 and 1977, listing destroyed benchmarks over a sheet, determining if a sheet has significant changes that warrant a new edition, etc.).

Microcomputers have many applications in cartographic areas (e.g., planning the location of rural health clinics (Bosanac et al, 1979), planning cuts and fills for highway design or laying out housing subdivisions (Hudgins, 1980) and teaching interactive cartography (Bowen and Charland, 1981). The microcomputer cannot handle extensive digital cartography such as topographic mapping without degradation of processing speed that may be unacceptable to many cartographers. The microcomputer of CIMS will allow many institutes to begin automation at a level that is fairly inexpensive and unsophisticated. Petrie (1981) catalogs some of the difficulties with digital mapping that a beginning country may encounter and these include a large capital investment, the lack of reliable electrical power, comprehensive technical support and a cadre of experts in computing and allied disciplines. The CIMS system provides the basis for future automation by introducing the benefits of interactive cartography and providing relatively uncomplicated and inexpensive hardware and software on which a new generation of cartographers may train.

CIMS Pilot Project

The Instituto Geografico Nacional de Costa Rica gave IAGS permission to use its collection of cartographic information in a pilot project. IAGS selected the 1:50,000 series sheet (ABRA) over San Jose, Costa Rica. The lithographic copy of the second edition of the sheet and approximately 36 overlays keyed to the base sheet were provided to IAGS. One cadastral sheet at 1:1,000 over central San Jose was provided to demonstrate that cadastral data could also be handled on the CIMS system.

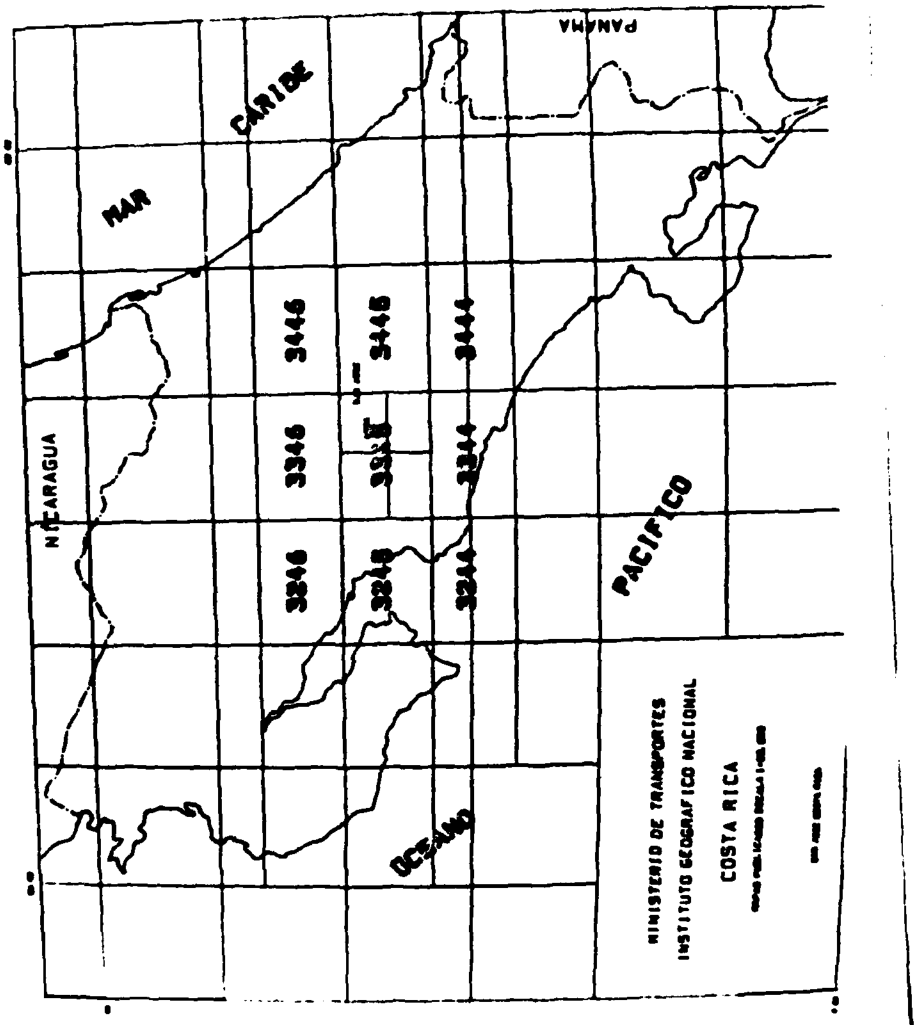
Synercom Technology, Inc. of Sugarland, TX, provided IAGS with computer time and technical support in working the pilot project. The Synercom system was viewed as a much larger and more powerful CIMS and was used more as a drawing and plotting system minus its analytical capabilities.

Approximately 15 overlays were digitized and include the cadastral sheet, 3 photography overlays, benchmarks, triangulation stations and other fairly basic information. The results of the pilot project are high quality plots of selected overlays and high quality slides of the CRT display showing different overlays of information, composites of overlays to demonstrate the decision-making possibilities and slides of the cadastral sheet.

System Use

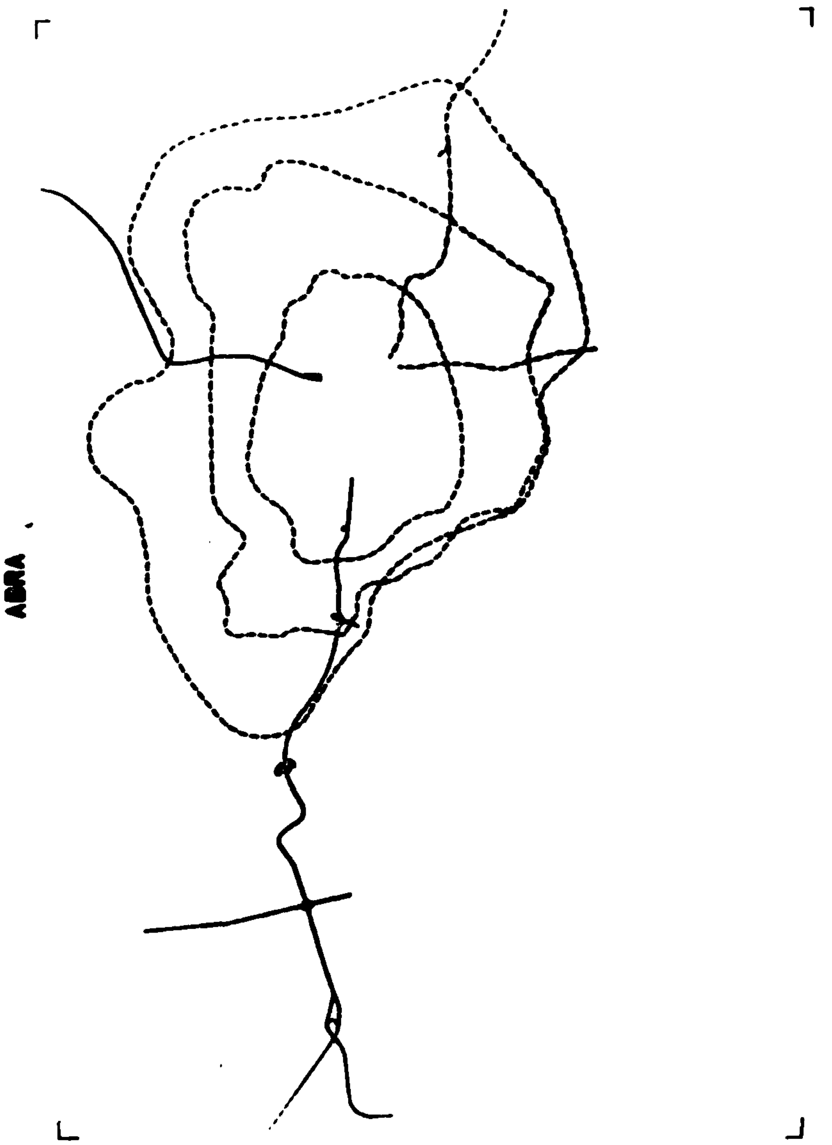
After data base construction, information is available to agency management personnel that is keyed to previously determined map series. To use CIMS, a management requirement is given to the operator who selects the map series index needed (in this case an index of the 1:50,000 topographic sheets) and then selects the sheet of interest (Figure 2). After selecting the base sheet, he can view this image or any overlay image by command. For example, Figure 3 depicts the future roads and Figure 4 represents the railroads over the sheet. The system operator may display overlays to view other map indices over the sheet, those representing available photography over the sheet or those depicting the available cartographic control. By command, the operator can composite combinations of overlays to aid his decision-making. Figure 5 is a composite of the cadastral index and the photogrammetrically derived control. From this image, a decision could be made to have the photogrammetry office derive control for cadastral sheets lacking such control. Figure 6 is a composite of the roads and railroads with a fictitious railroad added. Since the new railroad would be a significant change, this fact would be available to the software logic as it searches the data files in determining when sufficient, significant changes have occurred to require a new sheet edition.

Cadastral mapping is possible with a system similar to CIMS provided speed is not an essential factor. The system could be used as a display terminal for another, larger computer via a data communications interface if it is too slow as a stand alone system. A cadastral sheet over San Jose was



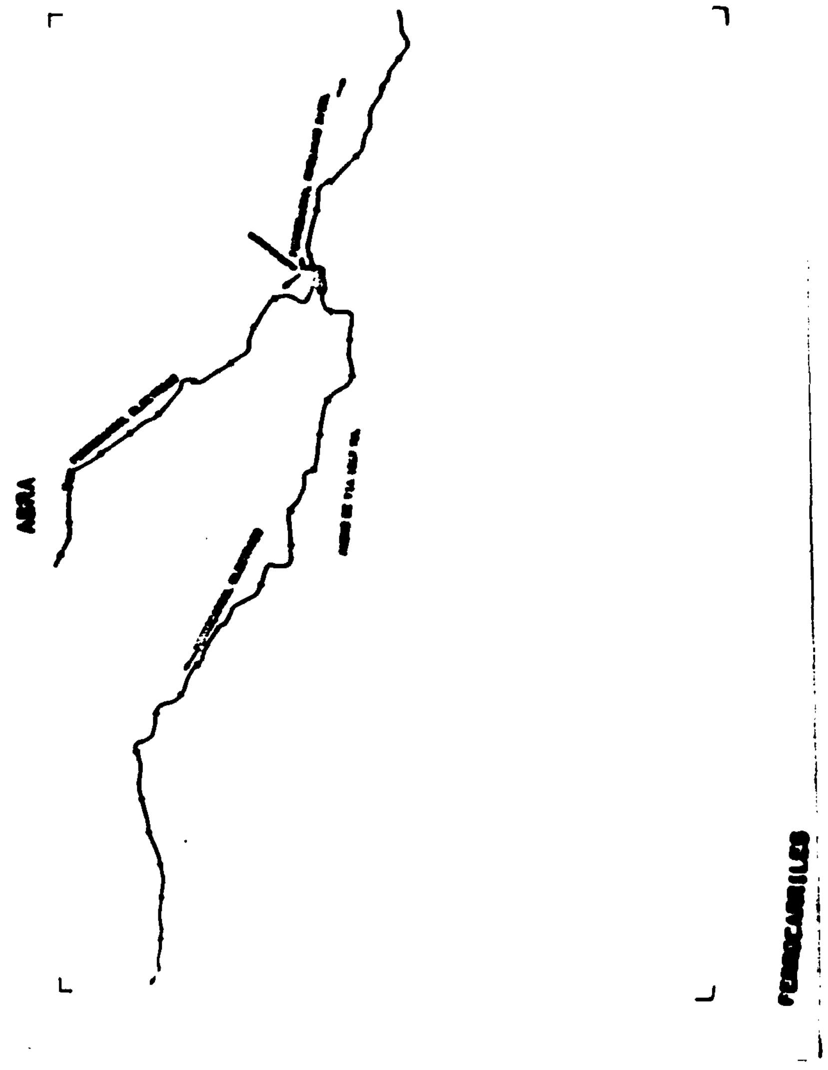
1:50,000 INDEX FOR COSTA RICA

Figure 2



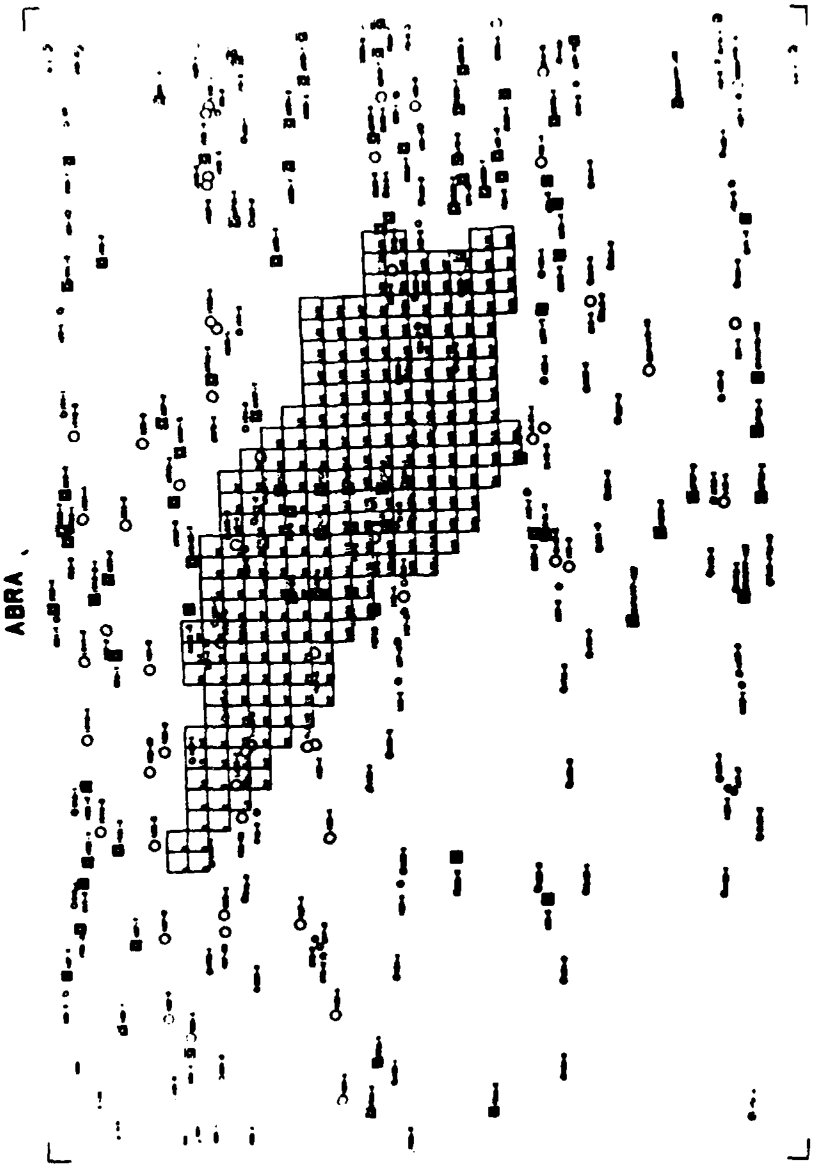
ROADS UNDER CONSTRUCTION OR PROPOSED

Figure 3



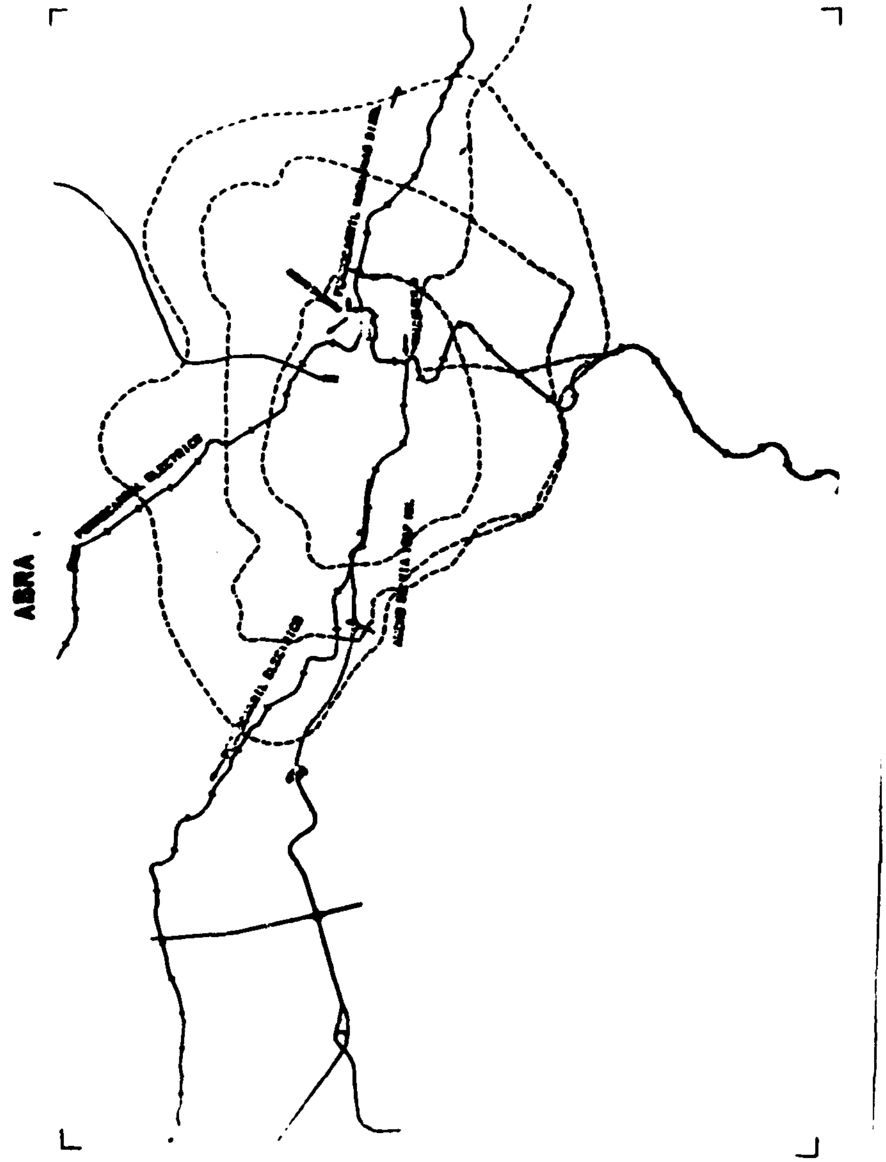
RAILROADS (ELECTRIC AND DIESEL)

Figure 4



COMPOSITE OF THE CADASTRAL INDEX
AND PHOTOGRAMMETRICALLY DERIVED CONTROL

Figure 5



COMPOSITE OF ROADS AND RAILROADS
(FICTITIOUS RAILROAD ADDED)

Figure 6

partially digitized (Figure 7) and parcel identification information was entered. Figure 8 is the resulting image and ownership identification of parcel 268.

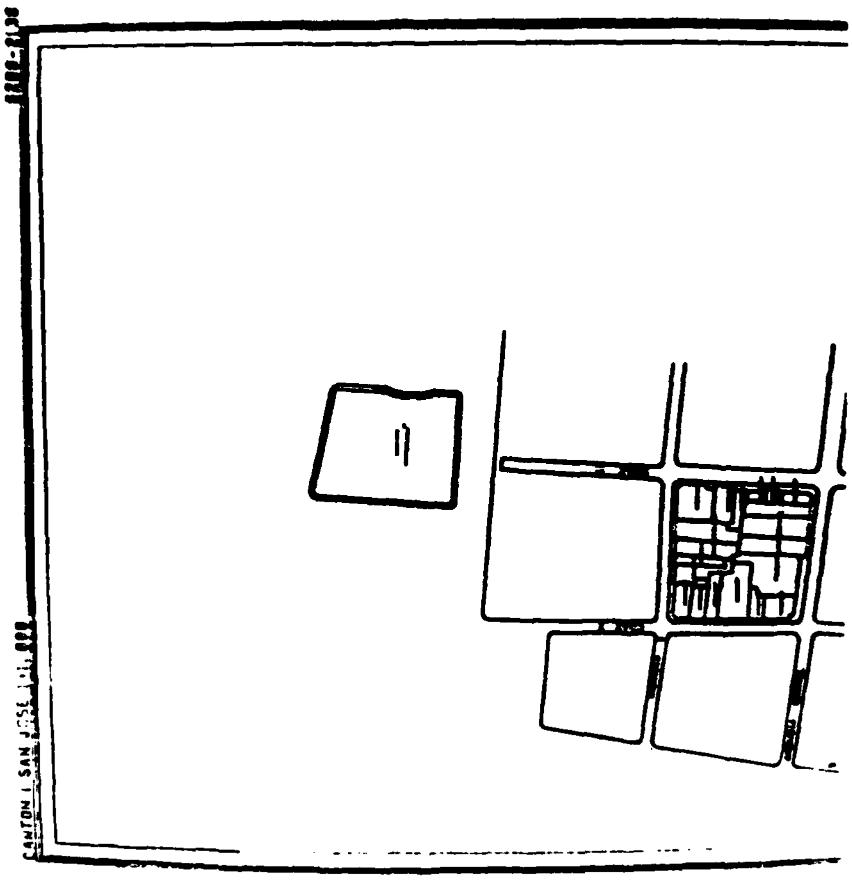
CIMS System Implementation

The system was specified and scheduled for installation at IAGS Headquarters in San Antonio, TX, for the winter of 1981. The software is a commercially available drafting package that will allow the basic requirements of CIMS (e.g., layering of information for selectivity purposes, cartographic labeling, interactive modification, etc.) to be satisfied. Analytical problem solving capabilities will be added by IAGS to reduce the amount of manual intervention and to modify the software for specific cartographic purposes. The software package will be available to IAGS' Latin American associates. Assistance will be provided to install the initial system as well as with any future IAGS modifications to enhance capability.

SUMMARY AND CONCLUSIONS

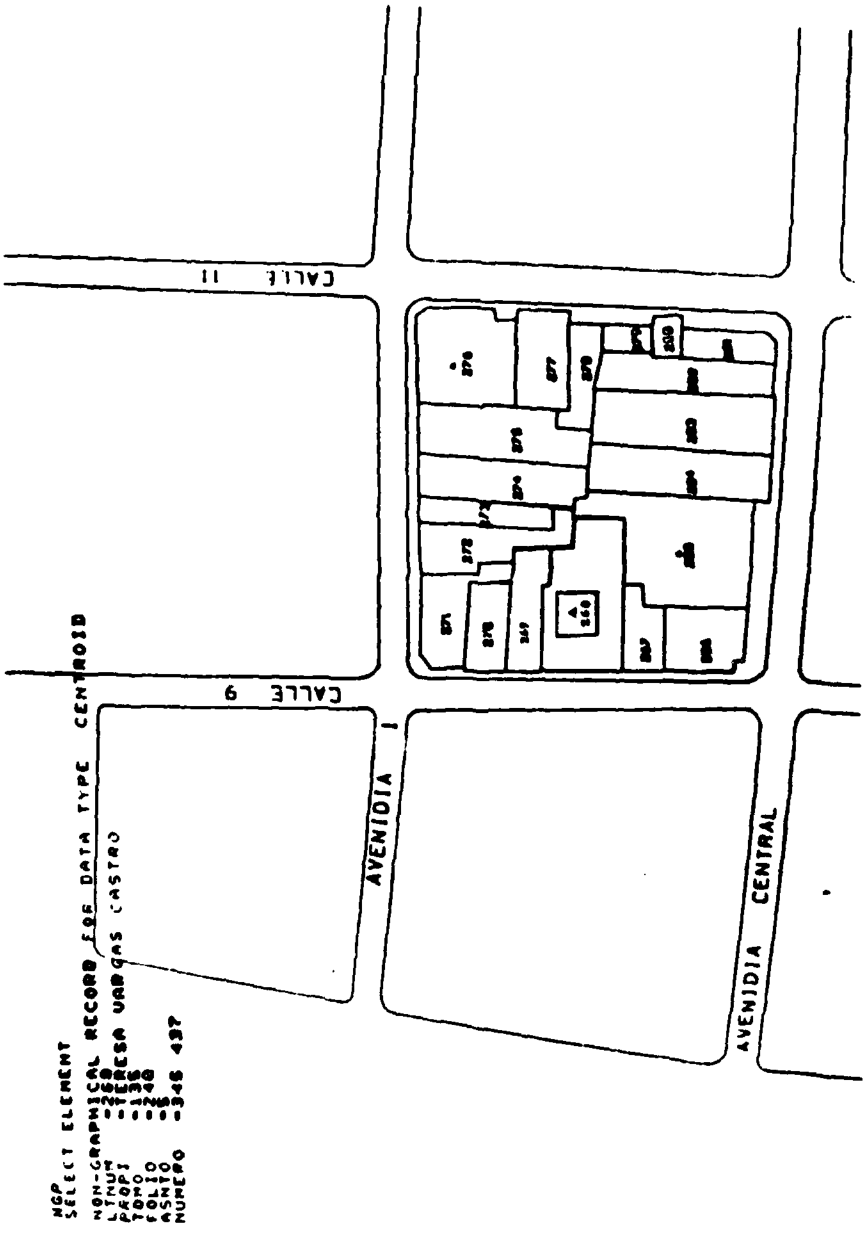
The CIMS system represents one of the fastest and simplest means of IAGS assisting interested Latin American cartographic/geographic institutes in applying automation to some of their problems. The system has several strong points such as, (1) the means to encode and store cartographic information, (2) the ability to rapidly display information that will allow cartographic managers to make decisions based on all the information available to an institute, (3) a low cost and simplicity of design so that an institute has a modest investment of resources (human and monetary) (4) the ability to handle other graphically related information such as cadastral and thematic mapping, and (5) the capacity to tie into other computers for additional processing power or to tie into a larger information system such as a national information display system connecting numerous government ministries.

A small system like CIMS is a natural learning tool that will introduce the uninitiated to the power of a computer and the communication possibilities of a graphic device. At the same time, the CIMS is designed to reduce or eliminate some of the factors listed (Petrie, 1981) that might impede the introduction and acceptance of digital mapping in a beginning country. Those factors include a large capital investment, the lack of reliable electric power, comprehensive technical support and a cadre of experts in computing and allied disciplines.



CADASTRAL SHEET OF CENTRAL SAN JOSE

Figure 7



FICTITIOUS OWNERSHIP INFORMATION-PARCEL 268

Figure 8

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